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Future Research of Science Parks and Incubators: overall analyses

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Abstract
Problems with the extant literature on science parks and incubators are examined in terms of four levels of analysis: the science parks and incubators themselves, the enterprises located upon science parks and incubators, the entrepreneurs and teams of entrepreneurs involved in these enterprises and at the systemic level. We suggest there is no systematic framework to understand science parks and incubators, that there is a failure to understand their dynamic nature as well as that of the companies located on them, that there is a lack of clarity regarding the performance of science parks and incubators which is associated with problems in identifying the nature of performance. We review briefly the papers contained in this special issue and demonstrate how each sheds light on an unexplored dimension of this emerging literature. In the concluding section, we synthesize the findings of the papers and outline a broader research agenda.

Keywords: research, cluster, science parks, innovation, incubators, and university transfer.

I. Executive summary

Science parks and business incubators are property-based organizations with identifiable administrative centers focused on the mission of business acceleration through knowledge agglomeration and resource sharing. A recent global increase in the level of activity of these institutions has stimulated an important academic debate concerning whether such property-based initiatives enhance the performance of corporations, universities, and economic regions. It has also led to an interest among policymakers and industry leaders in identifying best practices. This raises important questions related to strategy formulation by organizations that manage science parks and incubators and also for tenants of these facilities.

In this paper, we outline some problems with the extant literature on science parks and incubators. This is followed by a brief review of the papers contained in the special issue, wherein we demonstrate how each sheds light on an unexplored dimension of this emerging literature. In the concluding section of the paper, we attempt to synthesize these findings and outline a broader research agenda.

Science parks and incubators are examined in terms of four levels of analysis: the science parks and incubators themselves, the enterprises located upon science parks and incubators, the entrepreneurs and teams of entrepreneurs involved in these enterprises, and the systemic level. We suggest there is no systematic framework to understand science parks and incubators, that there is a failure to understand their dynamic nature as well as that of the companies located on them, that there is a lack of clarity regarding the performance of science parks and incubators which is associated with problems in identifying the nature of performance.

We suggest a number of avenues for further research.

First, there is a need to consider why science parks and incubators exist. An associated issue is to describe the ecology of incubators and science parks as a market for tenant firms. Further, we do not as yet understand the types of innovation market failure that science parks and incubators are designed to correct and in particular why they are uniquely able to address this issue. An important dimension of such analysis is to consider what specific as opposed to general resources (or factors of production) are offered by science parks and incubators, and to what extent these institutions are able to develop dynamic capabilities that will enhance their ability to assist new ventures.

A second area we identify is the need to employ a strategic approach to building models of science parks and incubators that considers issues of resource substitution and complementarily. For example, analysis of the extent to which incubators and science parks are substitutes for or complementary to venture capital firms would be one particularly fruitful area to explore.

Third it is evident that science parks and incubators take place in different environmental and institutional contexts, which are also dynamic. Although the papers in this special issue incorporate these aspects, there is a need for further development of a structural contingency perspective that relates different types of science parks and incubators to different contexts.

Fourth, while the papers in this special issue address systems-level issues and to a lesser extent, university- or regional-level issues, there is a need for considerable further

analysis of the science park and incubator level as well as the individual entrepreneur or team level. There is a dearth of studies that address issues concerning the governance of science parks. We suggest that an agency theory perspective may be useful in approaching questions of governance, with the likely presence and conflict of multiple principals as a particularly novel governance dimension.

Fifth, there is a need to consider the performance of science parks and the nature of this dependent variable. Survival is a particularly problematical measure given the different objectives of the various types of science parks and incubators. There is therefore a need to take into account the interaction between objectives and the nature of performance. Associated with this observation is the need to undertake further theoretical explication on the use of longevity or tenure as a dependent variable. This in turn is linked to the nature of governance and incentives for science parks and incubators. There is also a need to identify and examine the 'threshold issues' relating to enterprises' entry and exits from science parks and incubators.

Finally, the paucity of research on the individual entrepreneurs and entrepreneurial teams working for firms located on science parks and incubators is striking. The nature of entrepreneurs and their teams may have a particularly important influence on the ability of ventures to graduate from these institutions.

II. Introduction

A by-product of the technological revolutions in manufacturing processes and telecommunications in the early 1980s is the perception among policymakers and scholars that innovation results in wealth creation at the regional and national levels. Developmental and growth economists assert that an increase in the rate of investment in R&D can allow advanced industrial countries to compete with emerging economies, which have significantly lower labor costs in manufacturing and service industries. Another common perception is that new-technology-based firms are likely to be a critical source of new job creation.

This focus on the need to increase the population of small, high technology firms has contributed to a substantial increase in public and private spending on science parks and business incubators. We define these institutions as property-based organizations with identifiable administrative centers focused on the mission of business acceleration through knowledge agglomeration and resource sharing[1]. Many universities have established science parks and incubators to foster the creation of start-up firms based on university-owned (or licensed) technologies. Public universities (and some private universities) also view these institutions as a means of fostering regional economic development. Science parks and incubators have become an international phenomenon. The Association of University Research Parks (AURP) reports that there are 123 university-based science parks in the United States. The National Business Incubation Association (NBIA) reports that the number of business incubators in North America rose from 12 in 1980 to 950 at the end of 2002, while U.K. Business Incubation (UKBI) estimates 250 business incubators in 2002, rising from 25 in 1997. The U.K. Science Park Association reports that there were 32 science parks in 1989 and 46 in 1999. According to the European Commission's Enterprise Directorate General, there were 850 business incubators in the European Union, as of 2001).

In Asia, the first science park, Tsukuba Science City, was built in Japan in the early 1970s with other Asian countries following suit in the mid-1980s. Today, there are more than 200 science parks in Asia and still growing, with Japan topping the list at 111.

China, which built the first one in the mid-1980s, now has about 100.

India established 13 parks in late 1980s but with the exception of Bangalore, India's Silicon Valley, all have failed.

Hong Kong and South Korea report two parks each while Macau, Malaysia, Singapore, Taiwan, and Thailand have one each.

This increased level of activity has stimulated an important academic debate concerning whether such property-based initiatives enhance the performance of corporations, universities, and economic regions. More practically, it has also led to an interest among policymakers and industry leaders in identifying best practices. This raises important questions relating to strategy formulation by organizations that manage science parks and incubators and also for tenants of these facilities.

Unfortunately, few academic studies address such issues. This can be attributed to the somewhat embryonic nature of science parks and incubators and the fact that the organizations that have established these facilities, i.e., universities and governments, are nonprofit entities. This renders standard economic explanation assumptions invalid or in need of substantial modification. It is also important to note that science parks and incubators are often the result of public–private partnerships, which means that multiple stakeholders (e.g., community groups, regional, and state governments) have enormous influence over their missions and operational procedures. Thus, developing theories to

[1] The U.S.-based National Business Incubation Association defines a business incubator less specifically as ''an economic development tool designed to accelerate the growth and success of entrepreneurial companies through an array of business support resources and services''.

characterize the precise nature of their business models and managerial practices beyond simple descriptions has not proceeded very far.

Theoretically, there has been a recurring problem of definitions in which science parks and incubators can encompass almost anything from distinct organizations to amorphous regions. As such, the relevant government agencies (e.g., the National Science Foundation) have not collected systematic data on these institutions. Thus, there are no publicly available data for comparative analysis or benchmarking. This makes it difficult to conduct an econometric analysis of the antecedents and consequences of the performance of firms on such facilities and their impact on universities, regions, and other firms in the local region.

The purpose of this special issue is to begin filling these theoretical and empirical gaps in the literature, by providing the best available international quantitative and qualitative evidence. The special issue represents a subset of double-blind peer-reviewed papers presented at an April 2003 international conference held at the Rensselaer Polytechnic Institute in Troy, NY, USA. Three major themes emerged from this conference: the role of networks in business incubation, entrepreneurial strategies by firms, universities, and regions to exploit university created intellectual property, and the impact of science parks and incubator on firms and universities. This special issue features papers from a variety of theoretical perspectives such as the theory of the firm, institutional theory, resource dependence theory, agency theory, social capital theory, and organization learning; at multiple levels of analyses—firm, industry, region, country; that employ a mix of quantitative and qualitative methods to build and test theoretical frameworks.

In the next section, we outline some problems with the extant literature on science parks and incubators. This is followed by a brief review of the papers, wherein we demonstrate how each sheds light on an unexplored dimension of this emerging literature. In the concluding section of the paper, we attempt to synthesize these findings and outline a broader research agenda.

III. Reflections on the Literature on Science Parks and Incubators

Academic studies of science parks and incubators can be divided into studies that focus on the companies located on these facilities, those that attempt to provide an assessment of the science parks and incubators themselves, those that focus on the systemic level of the university, region or country, and those that examine the individual entrepreneur or teams of entrepreneurs in these facilities. Thus, there are four streams of research in the literature. From a theoretical perspective, efforts to connect these four research streams have not been very fruitful. First, that is because there is currently no systematic framework to understand the connection between these multiple levels of analyses, as there is, for example, for the relationship between the headquarters of a multinational corporation and its subsidiary office in or the relationship between a venture capitalist and an investee firm.

In addition to their multilevel nature, science parks and incubators are also dynamic. The mission and operational procedures of an incubator change over time, as the papers in this special issue illustrate. We have yet to encounter such a dynamic model.

Next, we observe that what constitutes an appropriate measure of performance for a business incubator still remains unclear. Specifically, few studies have explicated the level of analysis of the construct the performance of the incubator or the firms in the incubator. We know that simply locating in a business incubator does not guarantee success. In fact, apart from the location and administrative support advantages, the value of business incubators has been called into question. A serious problem with research in this area is that the typical dependent variable, the rate of firm survival (or failure), has little construct validity, since incubators are specifically designed to maintain and increase life span. In short, such studies are selecting on the dependent variable, which creates an endogenously problem. One way to deal with this is to choose to compare survival rates among different incubators (e.g., for different types of incubators), an approach that few authors have undertaken.

In addition to the general theoretical problem of identifying valid dependent variables, there is the normative problem of demarking the transition between the efficient (acceleration) and inefficient (life support) organizational form of the same entity. Lendner and Dowling and others have used the metaphor of a greenhouse to illustrate the growth acceleration orientation of a business incubator. However, it is quite easy for incubation to turn into life support, a metaphor with negative implications government bailouts, and the inefficient deployment of public resources. For example, Bollingtoft and Ulhoi (this issue) report that 50% of the companies in the incubator they examined remained in the incubator after 4 years.

Attempts to construct theories of science parks have proven to be quite difficult, due to the lack of systematic data collection. An exception is a series of studies conducted by the Centre for Small and Medium Size Enterprises at the University of Warwick created a matched-pair sample of on- and off-park U.K. firms that have been used successfully in a series of studies. Even so, much of what constitutes theory, on closer examination, is usually an inventory of typologies, and causations and outcomes. Perhaps no general theory is possible because the causes and consequences of science parks and incubators may be idiosyncratic to their geographic

locations, political and social contexts, and economic systems. However, to make such a conclusion at this time would probably represent a rush to judgment on very thin evidence, which is the why we believe this special issue is timely.

IV. Contributions of this special issue to the literature on science parks and incubators

In organizing this special issue, we have adopted the perspective that science parks and incubators are distinct organizations within the technological entrepreneurial value chain. This value chain comprises the set of organizations whose activities are linked by the successive transformation of resource and knowledge inputs to marketable outputs in the period leading to and shortly after the creation of a new firm. Science parks and incubators are the intermediate organizations that provide the social environment, technological and organizational resources, and managerial expertise for the transformation of a technology based business idea into an efficient economic organization. Therefore, to advance the research on science parks and incubators we first need to understand their role in the value chain.

This is the approach taken in the papers by Markman, Phan, Balkin and Gianiodis, and Clarysse, Wright, Van de Velde, Lockett and Vohora. Specifically, Markman et al. outline a model that links a university's knowledge assets (patents) to business creation in university- based incubators with university technology transfer offices (TTOs) acting as the intermediaries. The focus on universities is due to the fact that they are responsible for a large share of the technology-oriented incubators in the United States. Although there have been several field studies of university TTO licensing activities [e.g., Bercovitz et al., 2001; Siegel et al., 2003c; Mowery et al., 2001; Nerkar and Shane, 2003], they have largely been based on data from a set of elite research universities (e.g., Stanford, UC Berkeley, and MIT) or from a small sample of more representative institutions. These results may not be generalizable to the larger population of institutions that do not enjoy the same favorable environmental conditions. To build a theoretically saturated model of TTOs' entrepreneurial development strategies, the authors collected qualitative and quantitative data from virtually the entire population of university TTOs.

A surprising conclusion of the study of Markman et al. is that the most ''attractive'' combinations of technology stage and licensing strategy for new venture creation, i.e., early stage technology, combined with licensing for equity, are least likely to be favored by the university and thus, not likely to be used. That is because universities and TTOs are typically focused on short-term cash maximization, and are extremely risk-averse with respect to financial and legal risks. Their findings are consistent with evidence presented in Siegel et al. (2003c, in press), who found that university TTOs appear to do a better job of serving the needs of large firms than small, entrepreneurial companies and taken together the studies suggest that universities need to change their technology transfer strategies if they are serious about promoting entrepreneurial development.

The work by Markman et al. highlights the importance of identifying the interests and incentives for those who manage the technology transfer process and their interactions with those who manage the science parks and incubators and entrepreneurs who work in these institutions. Theoretically, the relationship between TTO managers, the university administration and entrepreneurs can be modeled as a multilevel agency problem. In the case of university-based incubators, an internal market for the efficient allocation of resources does not exist.

Thus, internal bargaining may drive decisions on technology transfer and new venture creation, which would bring to the fore the question of incentives versus university mission, as demonstrated by Markman et al.

More generally, we believe that a good explanatory model of incubators cannot be achieved without direct reference to the individuals or teams[2] involved in the creation and management of ventures in them. There is a paucity of research on the human capital of the administrators and entrepreneurs, and the opportunity identification process that occurs in science parks and incubators.

There are several interesting research questions:

- *Are there systematic differences in the demographics of entrepreneurs that locate on science parks and incubators compared with those involved in the creation of ventures outside these locations?*
- *To what extent do science park and incubator managers take an active role in identifying opportunities?*

Existing studies of entrepreneurs indicate that individuals scan the environment according to schemas and heuristics that confine the scope of their search. These schemas are found to be related to the level of education, demographic factors, and work experience. Thus, scientists in science parks and incubators may be those who have recognized the need for more help in identifying the market for their inventions. This brings in a discussion of the entrepreneurial team.

There is increasing attention to the phenomenon of

[2] For our purposes, defined broadly as the entrepreneur, TTO officer managing the transfer of intellectual property to startups, surrogate entrepreneurs, members of the research team, business development officers from the incubator or Science Park, venture capitalists, business angels, and nonexecutive directors.

entrepreneurial teams. However, this research has yet to explore the different contexts in which they are found. Team members can contribute the requisite range of human capital necessary to develop a venture that may not be available in a single individual. However, team heterogeneity may lead to increased level of conflict and the administrative inefficiency that it causes. When viewed dynamically, entrepreneurial teams can be seen to evolve with the entry of new team members who bring the requisite human capital at a particular stage and the exit of others when their contributions cease to be relevant. Thus, the extent to which science parks and incubators assist in team building as a venture matures should be seriously considered. Administrators of science parks and incubators may, for example, fulfill a team role in helping to identify a market for the innovation, providing intellectual property protection advice, offering business development skills, identifying surrogate entrepreneurs and venture capitalists.

The paper by Clarysse et al. follows the same inductive tradition, using qualitative analysis to document the ‘‘spinout’’ strategies of European research institutions. It employs a two- stage approach to developing and validating a set of seven ‘‘scientific regions of excellence’’ in France, Belgium, Germany, UK, and the Netherlands. Their case studies of these regions revealed three generic strategies (low selective, supportive, incubator) for managing the spinout process. The selective model is based on a ‘‘let a thousand flowers bloom’’ strategy that maximizes the investment options in highly uncertain technology start-ups. The supportive model is designed to maximize the survival odds of a start-up by providing extensive pre-start-up financial, technical, and administrative support. The incubator model is based on the clear goal of creating financially attractive spinouts. Each model is configured differently, in terms of its organizational, human, financial, technological, network, and physical resources.

An interesting finding from the study, which would not have been apparent if the authors had employed a large sample, deductive approach, is the revelation that two “suboptimal’’ categories existed: research institutions that are resource deficient and those that are competence deficient. Competence-deficient organizations have sufficient resources, but insufficient capabilities whereas resource-deficient ones may suffer from unrealistic expectations, as they tend to follow visibly successful start-ups in their immediate region.

The paper by Koh, Koh, and Tschang elaborates on this line of research. They outline an analytical framework for predicting the factors influencing the growth and evolution of science parks, based on a deductive analysis of three exemplars: Silicon Valley, the Cambridge Science Park, and the Hsinchu Science District. Their model considers three aspects of science parks that have been separately discussed in the literature but never together in a cohesive framework: growth mechanisms, sophistication of technological capabilities, and the degree of integration in the value chains of national and global markets. This framework is then used to evaluate an emerging science park strategy in Singapore.

As a contribution to the extant literature, the use of exemplars to build a theoretical model is simultaneously controversial and unique. Their work, and that of Clarysse et al., will be quite instructive to future researchers, especially those who try to deduce a general model from a set of well-known case studies. Typically, the use of individual case studies has been linked to inductive approaches to theory building. However, when multiple case studies are considered, general lessons may be deduced by looking for commonalities among the case studies. An issue with such an approach is the problem of left censorship, in which only successful exemplars or models are picked for building the general model. This can lead to an under specification of the model or worse, incorrect theoretical conclusions. Koh et al. avoided this in three ways. The exemplars they selected have been extensively studied in the literature and have themselves been the bases for entire streams of work on national innovation systems. Second, they were careful to anchor their conclusions on well-known theories, such as knowledge spillovers. Third, in testing the model by application to another case study, they were careful to limit their generalizations.

It turns out that the main growth mechanisms for the exemplar science parks are government-led infrastructure provisions that create opportunities for knowledge agglomeration and self-renewal through the continual creation of new businesses. Strong self-renewal capabilities result in new firm formation and a high level of sustained R&D. Silicon Valley evolved into a global hub for R&D because of its proximity to world-class universities and the world’s largest domestic consumer market. Hsinchu exploited Silicon Valley’s R&D capabilities by exploiting the overseas Chinese network already established in the Valley. Cambridge acted as a magnet for technology start-ups keen to take advantage of its proximity to a world-class university. In each of the exemplars the most important trait for creating and sustaining new technologies and products for the global market is the access to talent. In a sense, the authors’ framework reinforces some of the work by Saxenian (1991) and others but by making the science park central to the innovation network and highlighting the three success factors, they suggest a higher level of control over the trajectory of entrepreneurial intensity than previously implied in the literature.

They test the generalizability of their framework on Singapore’s evolving science park strategy and conclude that it represents an infrastructure-led growth strategy. According to the framework, they assess that whether these efforts would succeed would depend on how successfully the science park

can acquire the other success factors such as greater private sector participation, formal linkages with Silicon Valley and other successful science parks, and a continual supply of knowledge creating talent.

Both Clarysse et al. and Koh et al. highlight an important feature of incubators and science parks. Unlike stand-alone enterprises, these entities are deeply embedded in the political system. Publicly supported incubators and science parks are regarded as tools for economic development and political bargaining. First, there is an active internal bargaining process for resources, broadly defined as recognition, networking with external contacts, services, and so on, largely within the strategic core. There is also an external bargaining process with resource providers (governments, other companies, labor market, etc.). These processes are not necessarily driven or mediated by market forces because the combination of public funds and the political interests that control the disbursement of those funds mean that the 'efficient price' signal for a resource allocation decision becomes more noisy. Therefore, it may be that if incubators exist at the behest of political interests then without the support of those interests, incubators as an organizational form may not be very viable, which is often the case for nonprofit incubators. Putting all this together, one can reasonably ask if an appropriate research question may not be whether incubators lead to higher rates of success among start-up firms but rather in what ways do incubators confer legitimacy to the political interests that support them.

Continuing with the theme of assisted entrepreneurial value creation is the final paper by Bollingtoft and Ulhoi. Employing a qualitative methodology, the authors show that the "networked incubator", which they uncovered in their research, is a new hybrid form based on territorial synergy, relational symbiosis, and economies of scope. Using social capital theory[3] they conducted an ethnographic study of a single incubator and show that entrepreneurial economic decisions are made in a sociocultural and emotional (i.e., noneconomic) context. The existence of network ties between those involved individuals and organizations in the incubator suggests that the exchange of information and resources between firms in the incubator is influenced by social norms, social structure, and individual power. These, in turn, are determined by access to and relative position within the social network.

We believe that the contribution of this paper is to characterize the incubator as a means to address the liability of "newness" that all start-ups experience. In this context, newness refers to the lack of market visibility and connectedness with a resource network. The authors demonstrate that network theory and social capital theory can account for much of the social and business activities in a business incubator. On the other hand, their discussion forces us to ask if there is a theoretical difference between incubators and VC partnerships, corporate internal venturing units, and governmental economic development agencies. *If the definition of an incubator has to be more precise, then on what basis should this be done?*

Sociologically, incubators can be seen as micro communities of firms and individuals. As such, we anticipate that future studies will increasingly adopt the social network approach exemplified in the article by Bollingtoft and Ulhoi. It is appropriate to think more carefully about this approach, precisely because it appears to be so apt.

First, social networks and the accompanying analytical approach is a formal descriptive methodology for mapping out the relationships between entities that are tied together by resource and information flows. *How do the results of such analyses lead to normative theory, which should be the natural outcome of such research?*

Second, *is the network an appropriate metaphor for the incubator?* An incubator is a self-contained organization with an identity, set of routines, and a strategic core. It has an administrative center, a distinct mission, and interacts with the external environment as a unified entity. In many ways, the incubator (ignoring the differences across profit/ nonprofit, university or company based, etc., for now) is really a company and is organized as such. On the other hand, a true network has relatively more porous boundaries, is more informally organized, and is potentially more embedded than an incubator. In short, the level of analysis question has to be asked first.

V. An agenda for future research

So where do we go from here? Papers on incubators and science parks typically begin with two features: an enumeration of different types of incubators and a list of antecedents and consequence of some measure of success (sometimes, self-reported measures). For example, Clarysse et al. identified three types of incubators relating to the development of spinouts from research institutions, with the level of assistance ranging from perfunctory provision of physical space to detailed hands-on involvement. In contrast, Koh et al. suggest three dimensions that can describe most science parks. This suggests that the organizations we are dealing with are sufficiently idiosyncratic to ensure that developing a unified theory of incubators and science parks may be very difficult.

On the other hand, there do exist organizational theories that we can exploit. A general model of incubators and science parks should allow us to answer the following questions, which

[3] Resources embedded in a social structure and made accessible and mobile by purposive actions.

are standard for research into other organization forms but would represent advances to the extant research on this topic.

The first question is why do science parks and incubators exist, given that there is already a market for the exchange of resources typical of those provided by incubators? One might argue that high-technology incubators address an innovation market failure, if the commercial value of the technology being promulgated is so uncertain (in the sense of Knight, 1921) as to thwart the calculation of a discount rate. Hence, market forces do not result in financial and other support for the commercialization of the technology. In particular, if the likely social returns to the innovation would greatly exceed the private returns to these activities (see Mansfield et al., 1977, for an elaboration) an incubator, which is essentially an indemnification of the entrepreneur's risks from the public purse, may be the only solution. In practical terms, the incubation process may be the only way a start-up that exploits an embryonic technology can emerge.

An extension to this question may be to ask if one can describe the ecology of incubators and science parks as a market for tenant firms. With the exception of the work by Storey and Westhead on U.K. science parks, there is little existing evidence on the search processes adopted by firms concerning their decision to locate on a particular science park or incubator, and the intermediaries involved in the process. Theoretically, we can build models that characterize science parks and incubators as being in competition with each other and with other organizations such as corporations to attract tenant firms to co-locate in them. Research has shown that knowledge spillovers occur whenever agglomeration occurs. Therefore, these 'economic network effects' suggest that the larger the size of an incubator or science park, ceteris paribus, the more valuable the geographic location, and hence, the rents that can be extracted from tenants. Researchers can even contemplate the possibility of a cooperative, rather than a competitive solution, to this problem, which moves the level of analysis up a level to the network of science parks or incubators in a geographic region. Such approaches would augment the property-based studies that have been the mainstream of such research, but on a more appealing theoretical foundation.

Finally, in proposing that incubators and science parks are solutions to market failure, one can consider the types of innovation market failure (Martin and Scott, 2000) that they are designed to correct. Given the existence of quasiorganizational forms such as virtual networks, online marketplaces, application service providers (ASP) or other forms of exchange, a model must be capable of answering the question *"Why incubators and science parks are uniquely able to solve these types of market failures?"* One way to approach this question is to show that without incubators, a more efficient way to organize resources, whether by market exchange or a unitary hierarchy, would not occur because of information asymmetry, asset specificity, and/or resource stickiness. More specifically, because there are transactions costs attached to any organizational solution to market failure so an assessment of its efficiency and thus viability has to account for the economic value that it creates.

In addition to the market failure approach, we can also employ a strategic approach to building models of science parks and incubators. Here, we are concerned with issues of resource substitution and complementarily. Specifically, we can consider whether science parks and incubators substitute for institutional voids and how they offer something that is different from what is not available, or complementary, elsewhere. For example, *to what extent are incubators and science parks substitutes for or complementary to venture capital firms?* We believe that to the extent VCs and incubators are driven by different strategic objectives, the two types of accelerator organizations are complementary in the value chain of entrepreneurial value creation.

The issues of the unique contribution of science parks and incubators and of substitution and complementarily raise a key concern about the nature of their resources and capabilities. Science parks and incubators may be able to create greater value in the firms located on them if they possess specific, rather than general nonspecific, resources that are not available elsewhere. But their ability to learn from experience and develop their capabilities is also important in enhancing their ability to create value for their tenant firms. This highlights the need to consider the absorptive capacity of the science parks and incubators, and notably of their managers. Absorptive capacity relates to the ability of firms to recognize the value of new information, assimilate it, and apply it to commercial ends. We may also consider what Zahra and George (2002) refer to as "potential absorptive capacity", which comprises knowledge acquisition and assimilation capabilities, and "realized absorptive capacity", which centers on knowledge transformation and exploitation. Crucially, the former provides organizations with the flexibility to adapt and evolve in changing environments.

The papers in this special issue examine science parks and incubators in different environmental and institutional contexts. It is evident that there are similarities and differences among science parks located in the same geographic region and among science parks located in different geographic regions (Clarysse et al., this issue; Koh et al., this issue). This points to the need for a structural contingency perspective that relates the different types of science parks and incubators to different institutional contexts and objectives. For example, not all science parks and incubators focus exclusively on promoting technology intensive firms.

Together with the earlier discussion, we are suggesting

that institutional context is important enough for us to explicate it in the models that we build. It is also important to recognize that these environments are themselves changing as, for example, government policy objectives change or venture capital firms adapt their approaches to investing in companies located on science parks and incubators. In the light of our previous comment that the capabilities of science parks and incubators may develop over time through a process of learning, a central issue relates to the co evolution of science parks and incubators and the institutional and environmental context in which they operate.

Similarly, we need to consider the nature of the co evolution of the resources and capabilities of both the science parks and incubators, and their tenant firms. A co evolutionary perspective (Lewin and Volberda, 1999, in press) suggests that organizations and their environments evolve together and are interdependent. Longer-term survival involves organizations reconciling potentially conflicting pressures between stability and change to achieve fit with a dynamic environment. Such an approach may help, for example, in understanding how resource or competence deficient incubators (Clarysse et al., this issue) are able to enhance their competitive positions in the market for tenant firms.

In conjunction with the issue of institutional contexts is the level of analysis problem. Specifically, because incubators and science parks encompass independent organizations, they can be examined at different levels of analysis. These are the systems or national innovation level, the university or regional level, the science park or incubator level, the incubator firm level, and the entrepreneur and team level. All four papers deal with the systems and to a lesser extent, university or regional levels. Indeed this reflects much of the extant work because data is more readily available (e.g., governments regularly collect such data as part of accountability audits). This means that future research should move on to the Incubator or Science Park and lower levels of analyses.

At the highest level of analysis is the issue of the ownership and control. The differing and sometime conflicting objectives of the stakeholders in science parks and incubators raise questions about their governance. Rules concerning how long firms can stay on in an incubator is driven by governance imperatives and thus the governance mechanisms for monitoring the productivity of science parks and incubators becomes an important research question. In this regard, we feel that agency theory is an appropriate lens to frame the relationship between incubator and science park management and their stake- holders (e.g., Jensen et al., 2003, in the context of the university TTO). One can foresee how agency problems might be exacerbated in publicly subsidized incubators and science parks. That is because information on the value of resources and opportunities may be unreliable. This may result in a situation in which those firms least able to exist without subsidies are more likely to bargain hardest for resources and are consequently more likely to receive them.

Given that incubators and science parks are often the result of public–private partnerships, it is likely that there are multiple principals. This gives rise to a "principal–principal" agency problem where the primary agency problem is not the failure of professional managers to satisfy the objectives of diffuse shareholders, but rather the opportunistic behavior of the controlling shareholders. We expect that the magnitude of principal–principal conflict will be related to the extent to which each principal is able to maximize its parochial interests and also to the scope and value of the resources they provide. More importantly, because the value of particular resource bundles change as an incubator or science park evolves (and the firms in them), the relative bargaining power of the principals will also vary over time. Therefore, to the extent that principles of good corporate governance[4] are formalized and embedded in the management routines of these organizations, one can expect minimal impact from principal conflict. To the extent that they are not, principal conflict will lead to inefficiency in the resource allocation decisions of incubator and park administrators.

A research agenda is not complete without an in-depth discussion of the relevant dependent variables. In our introduction, we stated that there continues to be a question of the appropriate dependent variables and we believe that until there is progress on this issue, the models that we build can be challenged on grounds of theoretical validity. First, there is a need to consider survival per se versus wealth or job creation. The relative importance of these dimensions may be closely associated with the objectives of different science parks and incubators. We should also assess political, social, and economic objectives, and the interactions among them, which may influence the attention given to survival per se. The end result is that a more precise and meaningful evaluation of a science park or incubator would be based on broader outcome indicators including activities that are more likely to generate social returns or externalities to the region.

As an example, Siegel et al. (2003a) examined whether companies located on science parks report higher research productivity than comparable firms not located on these facilities. Their results suggest that science park firms are indeed more effective than nonpark firms, in terms of generating new products, services, and patents. These findings imply that university science parks could be an important mechanism for generating technological spillovers to local firms and regions.

Many studies on tenant firms use longevity or tenure as

[4] Encompassing questions of board arrangements, balance of stakeholder representation, board processes, strategic objectives, incentives and the incentive setting process for managers of science parks and incubators.

a dependent variable. This measure deserves further theoretical explication. For example, firms that depart from science parks may not exit as a result of failure but due to acquisition. This group may be either highly attractive firms with good economic prospects or may possess valuable intellectual and human capital even though they may be financially viable as independent entities. One approach to investigating this issue is to use event history analysis in which a hazard function is derived to explain the impact of various independent variables or covariates on incubator firm longevity or productivity.

On the other hand, firms that have had a long tenure in science parks may choose to remain because they cannot operate without the benefits of subsidized resources. Additionally, any explanation of the mobility of science park firms has to account also for the incentives of science park managers to maintain full occupation capacity. In the UK, only 49% of incubators in 2002 had a formal graduation or exit policy). There are two issues embedded in this observation. The most obvious is the governance question of incentives and measures of science park or incubator performance. The second, less obvious, has to do with the yet unanswered empirical question of whether these organizations possess the capabilities to develop their tenant firms to the point of graduation.

The upshot is that without more detailed data, it is not appropriate to compare the performance of such firms. For example, recent research on habitual entrepreneurs suggests that portfolio entrepreneurs in particular may start multiple activities on science parks and incubators as ‘‘experiments’’ and then close or merge them according to how they develop. This emphasizes the need to treat the entrepreneur as a level of analysis apart from that of the incubator firm because there are substantive implications for performance measurement. In sum, we believe that a fruitful research direction lies in the identification and examination of the ‘threshold’ issues related to venture firms’ entry onto and exit from science parks and incubators.

VI. Conclusions

Merriam-Webster’s Collegiate Dictionary (2003) defines *an incubator as “one that incubates: as a) an apparatus by which eggs are hatched artificially b) an apparatus with a chamber used to provide controlled environmental conditions especially for the cultivation of microorganisms or the care and protection of premature or sick babies”*. Created by public institutions and private firms, incubators and science parks attempt to create munificent environments in which new ventures are nurtured. Our current level of understanding of this process of ‘cultivation’ and ‘care and protection’ of premature businesses is still at the phenomenological stage. In this paper, we have attempted to demonstrate how the following papers in this special issue contribute to a more sophisticated theoretical discussion of this rapidly growing literature. We also provide some suggestions for a research agenda to leverage the research contained in this special issue.

We argue that science parks and incubators are important links in the entrepreneurial value chain at the national or environmental level of analysis. A theoretical model to explain the existence of such organizations has to account for the political and social institutions in which they are embedded. As a result, we believe that more theoretical rigor should be associated with the choice of a dependent variable in studies of science parks and incubators. For one thing, this variable will determine the generalizability of the models we construct. More critically, the dependent variable will drive the choice of our theoretical lenses, of which many can be brought to bear in developing such a model. Institutional theory may view incubation as an accelerated (albeit artificial) way to institutionalize new ventures. With respect to resource dependence theory, incubation may constitute a means to create resource buffers to absorb uncertainty. For agency theory, the incubating relationship could be modeled as way for venture capitalists to monitor entrepreneurial effort. Organization learning may characterize it as a form of knowledge accumulation and hypothesis testing.

Another issue we have identified concerns the multiple levels of analyses inherent in research on these property-based institutions. Incubators and science parks are obviously distinct organizations. However, they typically operate within officially or unofficially designated incubating regions—another level of analysis. Equally important is the notion that incubation is a form of individual mentorship between the incubator and science park managers and the entrepreneur or entrepreneurial team. Incubation can be a discrete activity, an ongoing process, or a context; all of which can be formal or informal, deliberate or emergent, rational or nonrational.

In conclusion, we observe that the theoretical questions and approaches are myriad, limited only by a researcher’s imagination and analytical tools. Hence, the opportunities for innovative, theory building and empirical analysis are enormous. Although the extant theoretical literature on incubators and science parks does not have an identifiable body of thought to drive future research, we believe that this special issue makes a small contribution toward that end. Such a body of literature is required to understand the purposes and values of these organizational arrangements and its future role in entrepreneurial development.

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